REVIEW REPORT

HESTVATN PROJECT

by the
HARZA ENGINEERING COMPANY INTERNATIONAL

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THE STATE ELECTRICITY AUTHORITY
ICELAND

HARZA ENGINEERING COMPANY INTERNATIONAL
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October 31, 1961

SUMMARY LETTER

The State Electricity Authority
P.O. Box 40
Reykjavik, Iceland

Gentlemen:

We have completed our review of the Hestvatn Project as developed by Mr. Sigurdur Thoroddsen and presented in his Project Plan Report. Our results are presented in the Text, Appendixes, and Exhibits which follow.

We have commented upon the overall aspects of the development as well as on the design of its various elements. Alternative designs have been suggested where considered appropriate, and are shown in a general manner in the Exhibits. The Project data given in "Appendix A" refers to the design as modified by us.

Our review of the project cost is presented in the form of an independent estimate, details of which are given in "Appendix B." Much of the basic information required for the estimate was provided in your letter dated August 28, 1961. A copy of this letter is attached as "Appendix C."

A summary of our findings is given in the introduction at the beginning of the text. The total project cost is estimated by us at $15,400,000 or equivalent to about 660 million Icelandic Kroners as compared to 655 million Kroners in the Project Plan Report. The close agreement is to some extent a coincidence because some individual items of cost show significant differences.

Preliminary estimates indicate that about 200 million kilowatt-hours of primary energy could be delivered annually to the existing system. Secondary energy would average about 40 million kilowatt-hours annually.

The estimated unit cost of firm energy is presented graphically on Exhibit 2 for a wide range of financing terms. We estimate that the cost of primary energy from the project will be from five to seven U.S. mills per kilowatt hour or 0.20 to 0.30 Icelandic Kroners for the most common range of interest rates.

The studies that we have carried out in conjunction with this review has been of great interest to us. We would like to compliment your staff and Mr. Thoroddsen on the thorough and comprehensive manner in which the potential of this resource has been investigated and studied. We will be glad to advise on any additional engineering work that you may wish to have accomplished.

Very truly yours,

E. Montford Fucik

E. Montford Fucik
Vice President

HESTVATN PROJECT

A REVIEW

INTRODUCTION

This report presents a review of the general design and cost estimate for the Hestvatn Project on the Hvita River as developed by Sigurdur Thoroddsen, and presented in his Project Plan Report. The project layout adopted is basically as outlined in our Advisory Report on the Hydro-electric Power Resources of the Hvita and Thjorsa Rivers, dated March 1960. It consists of the following elements:

1. A spillway weir on the Hvita River east of Hestfjall.
2. A diversion canal between the Hvita and Lake Hestvatn in the vicinity of the present outlet channel.
3. A headrace canal extending from the southwest end of the lake through the low saddle to the powerhouse, and
4. A powerhouse and appurtenances located on the right bank of the Hvita near the mouth of the Hlaupandi.

A 138 kilovolt transmission line from the powerhouse to the Ellidaar substation near Reykjavik has also been included in the cost estimate.

The project will develop about 15 meters of natural fall of the river between the diversion dam and the tailrace outlet. By raising the headwater about 2.5 meters to elevation 50.5 the total gross head developed will be about 17.5 meters.

It has been estimated that the project will deliver from the unregulated river flow about 200 million kilowatthours of firm energy as an addition to the existing power system in Southwest Iceland. Secondary energy on the order of 40 million kilowatthours could be produced annually on an average basis.

The dependable peaking capability was considered as 37,000 kilowatts from two initial units. The design provides for adding a third unit at a future time when the minimum river flow is increased by seasonal storage reservoirs. We have estimated the cost of the project to be as follows:

Productinn Plant	$ 9,544,000
Transmission Plant	1,916,000
Contingencies and Omissions	1,740,000
Engineering and Supervision	1,050,000
Interest During Construction	1,150,000
Total Project Investment	$15,400,000

This compares with the Project Plan Report estimate of 580,000,000 Icelandic Kroners or about $15,300,000 based on the exchange rate of 38 Kroners to one U.S. dollar used in the report. The two estimates are, therefore, very close with respect to total cost. There are, however, significant differences in individual cost items arising from modifications in the design as well as in the unit prices of work and cost of equipment.

The requirement of foreign currency is estimated at the equivalent of $10,000,000. The expenditure of local currency will be about 230,000,000 Krnners based on the rate of exchange of 43 Kroners to one U.S. dollar used in this review.

Of this amount less than one-half represents the cost of local labor and material whereas the remainder, equivalent to about $3,000,000 is for duties and taxes on imported equipment and material.

Our estimate is essentially of an appraisal nature aimed to establish the general level of cost that will serve as a basis for policy decisions on actual development. The plan presented is considered as technically feasible and not involving any serious construction or operation problems. A few minor modifications to the design as presented in the Project Plan Report are proposed; but these modifications have not affected the total cost estimate to any significant degree. Certain design aspects, notably those related to sedimentation problems in the reservoir, would need additional field investigation and study, possibly supplemented by model tests. We are convinced, however, that these problems can be satisfactorily solved as has been demonstrated at many existing projects of similar type that has been constructed on rivers of much higher sediment load than the Hvita.

The financing terms that can be obtained for the Hestvatn Project is not known at the present time. For this reason, we chose to present the annual charges as a function of the interest rate and for amortization periods of 25 and 40 years, respectively. The results are shown graphically on Exhibit 1. On Exhibit 2 is indicated the cost of energy per kilowatthour estimated on the basis of the firm energy estimate of 200 million kilowatthours production annually. For most common financing terms the cost of energy would range from five to seven mills* per kilowatthour of firm energy.

A tabulation of significant project data is included in Appendix A.

* One mill = $0.001.

BASIC DATA

This review was essentially based on information contained in the following English translations of reports on the Hestvatn Hydro-electric Project:

1. Project Plan Report by Sigurdur Thoroddsen, dated June 1961.
2. Hydrological Report by Sigurjon Rist dated July 1961.
3. Geological Report by Haukur Tomassnn dated June 1961.
4. Power Studies by Jacob Bjornsson, dated July 1961.

Other information used consisted of topographic and hydrographic maps, aerial photographs, bore hole logs, and results of permeability testing of the rock in the powerhouse area as presented in our report dated December 1960.

Basic information pertinent to estimates of costs such as labor rates, cost of material, taxes and duties to be included in the estimate were compiled by the State Electricity Authority and transmitted to us by letter dated August 28, 1961. A copy of this letter is included as Appendix C.

ENGINEERING FEATURES

Reservoir. We have tentatively selected elevation 50.5 meters as the normal operating level of the reservoir. This is one meter higher than assumed in the Project Plan Report and may cause some additional rise in groundwater levels under the low and flat grazing land along the left bank of the Hvita River. A large portion of the land is presently drained by Bauluas and other small creeks into the Hvita River which, during normal flows of less than 500 kiloliters per second, is two to three meters below the land surface. When the flow reaches a magnitude of about 1000 kiloliters per second the land becomes partially flooded.

Practically all land between the Hvita and the Thjorsa is inundated during floods of 1800 kiloliters per second or higher. Part of the water flows in that case south through channels east of the main river.

The spillway would be designed in such a way as not to reduce the hydraulic efficiency of the main river channel. The flood levels would therefore not be increased by the operation of the reservoir. In fact, the levels could be slightly lower because part of the water would be diverted through the powerhouse.

The relationship between the groundwater level and a given normal reservoir elevation cannot be predicted with certainty. Part of the water which is now drained into the Hvita through Bauluas could find its way southward and back into the Hvita downstream of the dam. The drainage path would, however, be several kilometers long so that considerable rise in groundwater may take place during heavy and/or prolonged rainfall. It is possible that a ditch from Olavsvellir to the Hvita downstream of the dam could provide adequate drainage for the land surrounding that farm.

From the viewpoint of power development the reservoir level should be as high as feasible because of the following advantages:

(a) Increased power and energy output.

(b) Less excavation in the diversion channel between the Hvita and Hestvatn and in the headrace canal between Hestvatn and the powerhouse.

(c) The entrance of the diversion canal could be higher, which would reduce the possibility of bedload and sediment being carried into the canal.

(d) Any problems associated with sedimentation of the reservoir would be reduced.

(e) The greater depth and reduced velocity through the reservoir would improve the conditions with regard to ice problems.

Based on judgement of all factors involved and on preliminary backwater studies it is our opinion at the present time that the normal reservoir level should be between elevations 50.0 and 51.0. Elevation 50.5 was tentatively adopted as the basis for the design of the hydraulic structures and for evaluation of the power output. The top of the gates at the spillway was, however, fixed at elevation 51.0 so that the reservoir could be raised to this level in the future, if feasible.

Our backwater studies show that the water surface will be practically horizontal at elevation 50.5 up to Hamrar for flows of 400 kiloliters per second or less. At the mouth of Bruara, about nine kilometers upstream of the dam, the water surface was estimated at elevation 50.8 for a flow of 400 kiloliters per second. This would be about 0.5 meters higher than under natural river conditions for the same flow.

Under natural conditions the river would be at elevation 50.5 at the entrance to the diversion canal for a flow of about 900 kiloliters per second. Since part of the flow would be diverted through the diversion canal this level could actually be lowered with fully opened gates at the dam.

On the assumption that 260 kiloliters per second is diverted through Hestvatn and the powerhouse, our backwater computations indicate that the spillway gates should be fully opened for total flows of about 1100 kiloliters per second.

The water level at the diversion canal would then be between elevations 50.5 and 51.0 or slightly below the natural level which is about 51.0 for 1100 kiloliters per second. For inflows between 260 and 1100 kiloliters per second the spillway gates would be partially open in accordance with an established "rule curve" determined in relation to a control point at the dam or the diversion canal or both.

The above discussion is based on the assumption that the hydraulic characteristics of the reservoir would not change appreciably after completion of the project. It is likely, however, that some aggradation will take place upstream of the dam until the river again reaches regime conditions. The aggradation may tend to raise the water surface so that flooding of the left bank may occur for lower flows than under the present natural regime. Additional field data and backwater studies are needed to determine the magnitude of the rise in water levels. It is possible that the aggradation can be reduced or even eliminated by river canalization methods as will be discussed hereinafter in the section, "Diversion Canal."

Compensation to the farmers for increased flooding and waterlogging of their land may be included eventually in the project cost. Such compensation could be arranged in several ways as outlined in our letter report "Proposed Program for Sediment Investigation, Hivta and Thjorsa Rivers, Iceland" dated September 2, 1961.

Diversion Dam. Our suggested design for this structure is little different from the one shown by Thoroddsen on drawing 5-2.1.01 and designated "First Dam Alternative." Twenty-five meter openings between the piers should be adequate for passing sheet ice that may accumulate in front of the dam.

There appears to be no reason for using roller gates instead of tainter gates as the latter are less expensive and would probably be more reliable in operatinn. We agree that at least two of the five bays should be provided with gates that can be lowered to permit the passing of floating ice without excessive use of water. The fishbelly flap gates proposed are well suited for this purpose and would probably not cost more than the tainter gates. In fact, the overall cost may be less because the piers would be smaller. There may, however, be some problems associated with operation of the flap gates as a result of formation of ice downstream of the gate and for this reason we do not recommend that all openings be provided with this type of gate. Some heating of the pit into which the flap gate is lowered may be necessary as well as heating of all gate guides and seals.

The structural design of the spillway as shown in the Project Plan Report is considered to be conservative. A design as shown on Exhibit 3 is considered satisfactory and will result in considerable savings in excavation and concrete. The total volume of concrete is estimated at 13,000 cubic meters as compared with Thoroddsen's estimate of 22,500 cubic meters. The top of the dam is at elevation 55.0 which should be entirely safe considering that the terrain on the left bank is at elevation 52.0 or lower. The spillway crest is at elevation 45.0 for the tainter gates and at elevation 46.5 for the flap gates, or slightly below the present level of the riverbed. The openings will have an area of 625 square meters to elevation 51.0 as compared to about 710 square meters for the natural section. Hydraulic model studies will be essential in final design, in order to verify the hydraulic adequacy.

The foundations for the dam should present no serious problems. Both the Thjorsa lava and the palagonite tuff and breccia that underlie the damsite will easily support the low structures contemplated. The contact between the tuff and the lava may contain talus and will require careful grouting in order to reduce seepage to permissible limits. Nominal curtain grouting will be required elsewhere and should extend about 50 meters beyond the left abutment of the dam. A grouting gallery underneath the dam is not proposed.

It is our opininn that a fish ladder will be required on both sides of the spillway as the fish may not be able to find the entrance to the ladder on the opposite side when the spillway is operating. The downstream entrance to the ladder should be located close to the spillway whereas the exit into the headwaters should be brought to a point upstream where the flow velocities would be sufficiently low as not to carry the fish back through the weir. The total length of each ladder would, however, be approximately as shown in the Project Plan Report. It is probable that the hydraulic conditions at the fishladder exit would be improved by placing a tainter gate at each end of the spillway rather than all three on one side, because tainter gates would give lower surface velocities under partial gate openings.

<u>Diversion Canal</u>. On the basis of a careful study of all available data we believe that the location of the canal should be approximately as shown by Thoroddsen for his Alternative 1. This route would require the least amount of excavation and would probably be superior to any other alignment as regards operation.

At the present time, however, the deep channel of the Hvita River is near the left bank whereas the right side of the river is quite shallow as a result of sediment deposits. It is desirable that this condition be reversed in order to improve the entrance conditions to the canal. This may be achieved by groins suitably placed from the left bank of the river. The groins will force the main flow towards the opposite bank and cause an increase in the velocities. The resulting erosion will probably lower the riverbed to about the same level as presently along the left bank, or about elevation 47.0. The canalization of the river should extend at least as far upstream as Hamrar and quite possibly one or two kilometers farther. Hydraulic model tests will be required in the final design to determine the best location of the groins. For the purposes of this review we have assumed that a total of six groins, each about 500 meter long, will be required. The top of the groins were assumed at elevation 51.0.

With canalization of the river as outlined we believe that the bottom of the canal at the entrance should be between elevation 47.0 and 48.0. Since the higher elevation will give the most conservative cost estimate, elevation 48.0 was assumed for the purposes of this review. A profile of the canal is shown on Exhibit 4. The canal is designed with a constant slope down towards Hestvatn where the bottom will be at elevation 46.0. From a width of about 250 meters at the entrance, the canal narrows to about 125 meters in the deeper section at the outlet into Hestvatn. Dredging of the lake at Vatnsnes will be required to provide adequate waterway into the deeper parts of the lake.

Occasional dredging may also be necessary when the project is in operation, to remove sediment deposited by the diverted water, but would not be a large element of annual costs.

The velocity of the canal for a flow of 260 kiloliters per second will vary from 0.45 meters per second with the water surface at elevation 50.5 to about 0.65 meters per second with the water surface at elevation 49.5. With these velocities an ice cover will probably form during cold periods and no serious ice problems are expected.

Field tests and further studies will be required to ensure that the canal will neither degrade nor aggrade over a period of time.

The canal through most of its length will be excavated in an organic soil consisting of silty clay with a surface network of matted roots and grasses. The side slopes should be conservatively designed; we have assumed four horizontal to one vertical. Excavation by dragline will probably be the most economical method. The excavated material should be placed at some distance away from the canal and/or spread in a thin layer in order not to endanger the stability of the canal embankments because of a surcharged load.

Near Vatnsnes, the canal will pass through deposits of gravel, sand, and silt that should cause no special problems. Lining of the canal is not considered necessary with the low design velocities assumed, but this assumption must be verified in the final design.

The canal will be about 1100 meters long and will require about 725,000 cubic meters of excavation. In addition, about 320,000 cubic meters must be removed by dredging in the Hvita riverbed and in Hestvatn near Vatnsnes. The headloss in the canal will be negligible.

Headrace Canal. We have no comments to make to the design of the headrace canal as presented in the Project Plan Report, except that the bottom of the canal could be raised about one meter as a result of the higher headwater levels proposed by us. A profile and sections of the canal for reservoir elevation 50.5 is shown on Exhibit 5. For the maximum flow of 390 kiloliters per second the velocity will be about 0.5 meter per second where the canal section is excavated entirely in soil. This occurs at the entrance near the shoreline of Hestvatn. The velocity will be about 1.5 meters per second where the hydraulic section of the canal is entirely in rock. The portion of the canal that will be in both materials, including a transition section at the entrance, will have velocities between 0.5 and 1.5 meters per second. The average total headloss in the canal is estimated at about 0.3 meters for a flow of 390 kiloliters per second and at 0.15 meters for a flow of 260 kiloliters per second. The most economical cross-section of the headrace channel should be determined eventually on the basis of an economic analysis which would compare the total value of the hydraulic losses and the annual costs for several alternative sections. The total excavation in the headrace canal is estimated at 400,000 cubic meters in soil and 195,000 cubic meters in rock. Dredging in Hestvatn will amount to an additional 120,000 cubic meters.

We do not envisage any ice problems in the headrace canal regardless of whether or not an ice cover will be formed. Because of the great depth of the canal it is unlikely that the water will be under-cooled sufficiently to form large amounts of frazil ice. An effective ice boom at the entrance as proposed by Thoroddsen designed to prevent sheet ice from being carried into the canal would in our opinion make an ice sluice at the powerhouse intake unnecessary.

Slush ice that may be formed in the canal could easily be passed through the turbines by removing the trashracks at the intake.

Intake, Powerhouse, and Tailrace. As suggested by Thoroddsen, the most favorable location of the powerhouse appears to be somewhere between the two sites selected for his Alternatives 1 and 2. In our study we have chosen a location about 75 meters downstream of Alternative 2 or about 200 meters from the right bank of the Hvita River, as shown on Exhibit 5. In this location the retaining walls required to contain the forebay would be not much higher than in Thoroddsen's Alternative 2, whereas the amount of excavatinn would be reduced substantially. It may also be feasible with this location to eliminate the somewhat elaborate access arrangement between the switchyard and the powerhouse shown for Alternative 2.

A section through a proposed arrangement of the intake, powerhouse and tailrace is shown on Exhibit 6. The principal difference between this layout and the one shown in the Project Plan Report is in the intake arrangement where we propose to use wheel gates instead of tainter gates. This will shorten the intake considerably and will also permit the construction of a center pier in each bay which will reduce the stresses greatly and thus the amount of reinforcement required. The trashracks will be well below the minimum operating level and will be made removable. The intakes can be closed off by a stop log arrangement at the nose of the piers.

As previously indicated, we do not believe that an ice outlet is needed. For the third unit we propose therefore that a skeleton intake bay be constructed initially.

The required stability could be provided by anchors into rock. The stability could also be improved by filling the enclosed space underneath the intake deck with rock as this space is not utilized for any other specific purpose.

The top of the intake is at elevation 54.5 which will provide one meter of freeboard above the design flood level. This should be ample in view of the very wide escape route the floodwater will have east of the Diversion Dam at this level. The intake deck will also serve as a road access across the headrace. The gate hoists will be housed in a gatehouse that may be heated with air from the powerhouse.

The unit spacing of 16 meters appears to be reasonable for the size of units contemplated. The setting of the units could, however, be slightly higher than indicated in the Project Plan Report for the tailwater conditions assumed.

The erection bay area shown in the Project Plan Report appears excessive and could probably be reduced in the final design. The access shaft from the switchyard could be avoided by locating the switchyard in the same relationship to the powerhouse as in Alternative 1. This will involve the excavation of about 50,000 cubic meters, mostly soil, but the cost of this work will be partly offset by improved foundations for all structures. We have assumed in our estimate that the switchyard and erection bay will be in approximately the same relationship as in Thoroddsen's Alternative 1. The general location of the fishladder as shown in the Plan Report, Alternative 2, is considered satisfactory except that the entrance to the ladder should be closer to the powerhouse.

The ladder could be one of several proven designs; the size and slope indicated by Thoroddsen is probably satisfactory. At the exit into the headwater it will be necessary to provide a control weir that can regulate the flow into the ladder for the entire range of headwater elevations. The amount of water required for the fishladder shown in the Project Plan Report is estimated at about 0.7 kiloliters per second for normal tailwater conditions.

We propose to make the tailrace channel slightly shallower but wider than shown in the Project Plan Report. We believe that this will improve the hydraulic efficiency on the basis of natural tailwater conditions and would also be more convenient from the construction viewpoint, thus less costly.

We understand that it may be possible to lower the tailwater levels by blasting a rock barrier that extends across the Hvita River a few hundred meters downstream of the powerhouse site. This matter should certainly be investigated further, as the gain in head may enhance the economics of the project. The data available at the present time are however not sufficient to form a basis for a considered opinion. We have therefore, for the purposes of this review, made the assumption that the suggested tailwater improvements would not be feasible.

The intake and powerhouse will be located in the Kambar formation of palagonite rock and basalt sills. The rock is eminently competent with very low permeability. A nominal amount of curtain grouting will be required to seal off fissures and joints in the otherwise watertight rock.

TURBINES AND GENERATORS

The maximum operating head on the turbines will be about 18 meters and the minimum about 15 meters.

Fixed-blade propeller turbines may therefore be advantageous economically if also the variations in load would be limited. This may not be the case, however, and at least one turbine should therefore be of the Kaplan type. As only two units will be installed in the initial stage, we recommend that both be of the Kaplan type. The extra cost of the Kaplan turbine, estimated at about $80,000, would be partly offset by reduced engineering costs both mechanical and civil. The overall efficiency would also be improved slightly. It is quite possible, however, that the third unit to be ordered and installed separately at a later date could be a propeller turbine especially if the design of this unit would be different from that of the initial units.

The sizing of the units needs additional study. Based on judgment and evaluation of all known factors we believe that the size adopted for the Project Plan Report is reasonable, but this opinion must be verified by power studies in the final design. Such power studies should compare several alternative power installations. The power study reported by Jakob Bjornsson for an assumed installation of 33,000 kilowatts was essentially for the purpose of determining the approximate level of firm energy production from two units considered as an addition to the existing power system. It was not for the purpose of determining the optimum plant capacity, but rather for comparison of the Hestvatn Project with other alternative sources of power. The study was based on the natural water supply in the minimum year 1950-51 and shows indirectly that somewhat smaller units than selected could be used without reducing noticeably the amount of energy that could be delivered to the system. However, such factors as future regulation of the natural river flow, value of secondary energy, peaking capability and reserve capacity were not considered.

In the ultimate development of the Hvita River approximately 1000 million cubic meters of storage may be available for flow regulation. A brief study based on flow regulation curves presented in the Hydrological Report shows that the minimum regulated flow with this amount of storage would be in the order of 220 kiloliters per second. With average total turbine discharge of 390 kiloliters per second from three units as assumed in the Project Plan Report the annual plant capacity factor would then be 57 percent. The plant capacity factor could, however, be considerably higher in average and above average water supply years. For the purposes of this review we have not assumed any change in the turbine capacity.

The average net head will be about 16.5 meters or one meter less than the maximum gross head as a result of hydraulic losses and average drawdown of Hestvatn for daily regulation. The turbine output at this head and at best efficiency was estimated at 26,000 metric horsepower. To maintain this output at the minimum net head of 15 meters, the full gate capacity at this head will be about 150 kiloliters per second. The centerline of distributor should be not higher than 0.5 meters above lowest tailwater with the selected speed of 136 revolutions per minute. The power factor of 0.8 assumed in the Plan Report is lower than considered necessary or desirable. A power factor of 0.9 was assumed by us in determining the generator rating and for establishing the transmission facilities. The generators were rated at 22,500 kilovoltamperes (kva) or approximately six percent above the turbine output at average head and best efficiency. The generators were designed for ten percent continuous overload.

TRANSMISSION SYSTEM

The transmission voltage of 138 kilovolts as proposed in the Plan Report for the 65 kilometer line to Reykjavik appears to be reasonable for the loads contemplated. This voltage would in addition facilitate a tie-in with the existing 138 kilovolt system from the Sog power plants. The conductor size selected is ACSR 336.4 MCM.

Being the most economical type of construction, wood-poles are proposed for the entire line from Hestvatn to Reykjavik. This type is now quite common for voltages up to 161 kilovolts both in Europe and the United States. Experiences in Scandinavia indicate that the method is successful also under severe icing and wind conditions.

The accessory electrical equipment indicated on the single line diagram in the Project Plan Report is considered adequate as the basis for a realistic cost estimate. The arrangement of the 11 kilovolt busbar is slightly different from standard American practice but no changes were assumed in our estimate.

The 69 kilovolt line to Hvolsvallar and the 11 kilovolt lines to the local power systems and to the Diversion Dam are not included in our estimate except for the necessary provisions at the Hestvatn Substation.

The transmission losses are estimated at about 3 percent under full load from the initial installation of two units and at 4-1/2 percent under full load from the ultimate installation of three units.

POWER AND ENERGY

The power and energy output will be increased as compared to the values computed in the power study by Jacob Bjornsson because of the higher reservoir elevation assumed.

The average net head is estimated by us at 16.5 meters as compared to 16.0 meters used in the power study. The corresponding increase in output will be about three percent. The overall efficiency of 81 percent that was assumed in the power study is comparable with our estimate of average efficiencies as listed below:

Water Conductors	1.00	(all hydraulic losses included in estimate of net head)
Turbines	0.90	
Generators	0.97	
Transformers (2)	0.99	
Transmission	0.97	
Station Service (including fish-ladder)	0.98	
Total	0.82	

The total energy output from two units at Hestvatn firm to the assumed load when operated integrated with the existing system was estimated by the SEA at about 200 million kilowatthours in the minimum water supply year 1950-1951. It should be recognized, however, that in the loading sequence used in the study, the Hestvatn Project was placed before Irafoss and Ljosafoss. In other words, the Hestvatn Project carried proportionally more of the load than Irafoss and Ljosafoss during periods of abundant water supply. However, as the output from the plant with maximum reservoir elevation 50.5 will be about 3 percent higher than assumed for the Power Study we believe that 200 million kilowatthours firm energy is a reasonable estimate at the present time.

This corresponds to an annual plant capacity factor of 61 percent.

A rough check based on the assumption that the monthly plant factor would not exceed 75 percent gives as a result the following monthly outputs for the minimum year 1950-51:

Month	Average Plant Factor	Output
September	67%	16.5 M Kwh
October	70	17.9
November	64	15.8
December	75*	19.0
January	75*	19.0
February	63	14.3
March	60	15.2
April	65	16.0
May	75*	19.0
June	75*	18.5
July	75*	19.0
August	75*	18.5
Total:		208.7 M Kwh

* Some water spilled

This appears to support the findings in the Power Studies.

We have estimated on the basis of the flow duratinn curve for the years 1950-1958 that the secondary energy produced would average 40 million kilowatthours annually. We assumed that the water utilization factor would be 90 percent during periods when the water supply would equal or exceed the turbine flow capacity.

The main portion of the secondary energy will be available in average and high water supply years. It is likely, however, that during such times there will also be an abundance of water available at existing hydroelectric plants. We decided, therefore, not to include possible benefits from secondary energy in the estimated unit cost of firm energy shown on Exhibit 2.

Regulation of the natural river flow will be required prior to the installation of the third unit. As a rough estimate, the total firm energy production will be about 260 million kilowatthours under probable ultimate regulated conditions. Secondary energy is then estimated to average 20 million kilowatthours annually.

COST ESTIMATES

General. Our review of the cost was carried out as an independent estimate based on the modified design as indicated on Exhibits 3 through 6. The estimate represents our present best judgment of unit prices and lump sums for the various items and are expressed in U. S. dollars. The various elements were arranged for presentation in a form which we have found convenient and more or less standard for estimates of this type.

Our cost estimates are presented in Appendix B which includes a summary estimate for the overall project and detailed estimates for the two main elements:

(1) The Hestvatn Project and (2) the Transmissiinn plant including the substation at Hestvatn, the extension of Ellidaar substation and a tie-in with the substation at Irafoss. The Hestvatn Project is further divided into the following subfeatures: (1) Intake and Powerhouse, (2) Reservoir, Dams, and Waterways including the Diversion Dam, Diversion Canal, and the Headrace and Tailrace Canals, (3) Turbines and Generators, (4) Accessory Electrical Equipment, (5) Miscellaneous Power Plant Equipment and (6) Roads. Import duties and taxes were incorporated into the unit costs and lump sums of the various items. The cost of land and land rights was omitted in our estimate as was also the case in the Project Plan Report.

Basic Data. The basic information for the cost estimates were provided in a letter to us from the State Electricty Authority, dated August 28, 1961, a copy of which is included as Appendix C. This letter contains data required on labor rates, cost of materials, exchange rate, taxes and duties in order to provide a realistic estimate under Icelandic conditinns.

The costs of machinery and equipment were based on actual costs and bid prices which we have compiled. European price levels were assumed for all mechanical and electrical equipment.

Our assumptions for the cost estimates appear to agree very closely with those made by Thoroddsen in his Project Plan Report with one exception. This is in regard to the currency exchange rate which was 38 Kroners to one U. S. dollar at the time when the Plan Report was being prepared. It has subsequently been changed to 43 kroners to one dollar and this rate was therefore used in our estimate. However, since there has also been a resulting increase in the wages of local labor, the net change on estimates expressed in dollars is very small.

Civil Engineering Features. Our estimate of the civil engineering features is based on computed quantities and unit prices for the principal items of construction, such as excavation, concrete, reinforcing steel, and structural steel. Appropriate lump sum items were used when sufficient information was not available to make an estimate of quantities or when the total cost of a structure or element of construction could be established adequately without a breakdown of quantities.

The quantities were computed from Exhibits 3 through 6 supplemented by the drawings in the Project Plan Report and sketches of specific structures as considered necessary.

The thicknesses of concrete and the amount of reinforcement required were estimated on the basis of our experience with similar structures on completed projects.

For some items, the quantities given by Thoroddsen were accepted without a detailed estimate by us. This procedure was used for the concrete in the powerhouse substructure and superstructure. We did, however, check these quantities against emperical values established by us for similar powerhouse structures and they were found to be comparable. The lump sum items for access roads and operators village given in the Project Plan Report were not checked and were included in our estimate unchanged.

The unit prices were computed on the basis of labor rates and cost of material as given in the letter from the State Electricity Authority, dated August 28. The cost of construction equipment was assumed at the prevailing hourly rates in the United States plus 25 percent to cover freight to Iceland and import duties and taxes. Our prices also include contractor's profit and overhead items including temporary access and accommodation.

Turbines and Other Mechanical Equipment. Our estimate for the turbines and governors was based on a recent bid price for a similar unit. This price was checked against emperical values of cost per horsepower adjusted to European price level. All costs represent that for the items completely installed and include taxes and duties estimated at 30 percent of direct cost including installation. Our estimate for the turbines agrees very well with that in the Project Plan Report which was obtained from the Swedish turbine manufacturer, Karlstad Mekaniska Verkstad. Independent lump sum estimates were made of miscellaneous mechanical equipment.

They agreed closely with those in the Project Plan Report.

Generators, Transformers, and Accessory Electrical Equipment. Our estimates for electrical equipment was based on equipment of Western European manufacture. All costs represent that for the items completely installed and are on a lump sum basis generally. They include import taxes and duties estimated at 30 percent of direct cost including installation for the generators and 35 percent for all other electrical equipment. The cost of the generators estimated by us is slightly lower than that in the Plan Report. This difference is offset, however by somewhat higher cost for the accessory electrical equipment in our estimate. It should be noted that the kilovoltampere rating of the equipment in our designs is lower than in the Project Plan Report because of the higher power factor assumed.

Transmission Plant. The transmission plant includes the 138 kilovolt single circuit line to Reykjavik, the Hestvatn Substation, the tie-in with Irafoss and the extension of the Ellidaar Substation. The cost estimate is based on equipment delivered from Western Europe and includes taxes and duties at 35 percent of the estimated direct cost of the equipment fully installed. The cost of land and land rights was omitted in the estimate. Information received on Norwegian wood-pole construction indicates that the cost of a 138 kilovolt single circuit line is about 90,000 Norwegian kroners, or about $12,500 per kilometer. This compares with our estimate of $10,000 per kilometer excluding taxes and duties. The comparison appears reasonable because constructinn in Iceland would be easier than in the hilly and forested terrain of Eastern Norway.

Contingencies and Engineering Costs. A contingency item of 15 percent was applied to all costs as an allowance for omissions and possible increases in quantities or prices. We consider this percentage to be reasonable in this case on the basis of the field data available and the engineering studies that have been carried out.

Engineering and owners overhead was estimated at eight percent of the direct construction cost. This value is based on our experience from similar projects and includes the engineering supervision of construction.

Interest During Construction. The financing terms that can be obtained for the Hestvatn Project is not known at the present time. It is possible that such terms will be different for local and foreign currency and also that the financing of the transmission plant may be under different terms than for the production plant.

However, for the majority of hydroelectric projects that we have been associated with both in the United States and abroad, the net cost for interest during construction is between 2 1/2 and 3 1/2 percent of the total construction cost per year. We believe that the construction of the Hestvatn Project can be accomplished in about 2 1/2 years. On this basis, the cost of interest during construction would normally be between six and nine percent of total construction cost including engineering. For the purposes of this estimate, we assumed the cost of interest during construction to be eight percent of the total construction cost.

Comparison of Cost Estimates. A comparison between the direct construction costs given in the Project Plan Report and as estimated by us, is tabulated below:

Item	Project Plan Report*	Harzint
Diversinn Dam	$2,190,000	$1,826,000
Diversion Canal	520,000	641,000
Canalization	53,000	280,000
Headrace, Tailrace Intake & Powerhouse	3,650,000	3,571,600
Fishladder (Powerhouse)	110,000	210,400
Hestvatn Switchyard (foundations only)	25,000	70,000
Turbines & Generators	2,370,000	2,290,000
Electrical & Mechanical Equipment	760,000	1,061,000
Roads	125,000	125,000
Operators Village	80,000	80,000
Contractor's Camp	210,000	___**
Transmission Line and Irafoss & Ellidaar Substations	1,160,000	1,305,000
Total	$11,253,000	$11,460,000

* Based on exchange rate: 38 Icelandic kroners = one U.S. dollar.

**Included in unit prices.

The largest single difference is in the cost of the electrical and mechanical equipment for the Hestvatn powerhouse and switchyard where our estimate is $300,000 higher than in the Project Plan Report. This difference is, however, partly offset by our lower turbine and generator costs. Differences in civil engineering items can in general be traced in changes in design or design assumptions as discussed in the Sectinn "Engineering Features".

Our estimate shows the total direct construction cost to be about $200,000 higher than in the Project Plan Report.

However, since our estimated cost of interest during construction is about $100,000 less the total difference in the estimated project investment is reduced to $100,000.

ANNUAL CHARGES

The annual charges against a power system include interest on invested capital, depreciation of the installation or amortization of investment, operation and maintenance expenses, insurance, and taxes.

We have estimated operation and maintenance expenses of the Hestvatn Project and the transmission plant to be $240,000 per year. Insurance would normally be in the order of one tenth of one percent of the project investment or about $20,000 annually. Taxes have not been included in our estimate.

Interest and amortization service ordinarily represents the major portion of annual costs for a hydroelectric project and are dependent on financing terms which at the present time, are unknown. We therefore computed the debt service for several interest rates and for both 25 and 40-year amortization periods. The results are shown graphically on Exhibit 1. The values given by the curves include all estimated annual charges except taxes.

COST OF ENERGY

The unit cost of energy is arrived at simply by dividing the annual charges with the amount of firm energy produced in a year. If we, as previously discussed, assume that 200 million kilowatt hours would be produced and delivered to the power system annually the cost of energy will be as shown graphically on Exhibit 2.

The curves show the cost of energy delivered on the low tension side at Ellidaar for interest rates ranging from three to seven percent and for amortization periods of 25 and 40 years. Taxes that may be levied on the operation of the power plant are not included in the estimated unit cost of energy.

For most common financing terms, the cost of firm energy will be between five and seven mills (U.S.) per kilowatthour. With an interest rate of five percent and 40 years amortization, the cost will be about six mills per kilowatthour. If the project could be exempt from import duties and taxes, the cost of energy would be reduced by about one mill. The value of the secondary energy that may be produced can not be predicted with any reasonable certainty at this time. We estimate that the crediting of income from the sale of secondary energy to the annual costs would result in decreasing the estimated unit cost of primary energy by two-tenths of one mill for each mill per kilowatthour received from the sale of secondary energy.

HESTVATN PROJECT

TABULATION OF SIGNIFICANT DATA

Streamflow	
Drainage area	4,360 km^2
Maximum discharge of record	2,500-3,000 kl/s
Lowest daily mean discharge	70 kl/s
Average flow 1950/51-1959/60	270 kl/s
Average flow dry year 1950/51	195 kl/s
Lowest monthly average (March 1951)	155 kl/s
Available 95% of time	150 kl/s
Reservoir	
Normal operating level	El. 50.5
Minimum operating level	El. 49.0
Maximum flood level (Q=4, 500 kl/s)	El. 53.5
Tailwater (Without river channel imporvement)	
Riverbed (Zero Discharge)	El. 31.0
For discharge 130 kl/s	El. 32.4
For discharge 260 kl/s	El. 33.0
For discharge 390 kl/s	El. 33.2
Maximum flood level	El. 36.0
Head	
Gross head (Q=260 kl/s)	17.5m
Average gross head (Q=260 kl/s)	17.0m
Average net head (Q=260 kl/s)	16.5m
Minimum net head	15.0m

Dam

Material and type	Concrete weir
Overall length, approximately	200m
Maximum height	13m
Gates:	
(a) Tainter crest gates	3 - 25m x 6m
(b) Fishbelly flap gates	2 - 25m x 4.5m
Fishladder	
Length	100m
Slope (horizontal to vertical)	10:1
Spillway Capacity -	same as river channel

Diversion Canal

Length between Hvita and Hestvatn	1,100m
Bottom elevation at entrance	48.0
Bottom elevation at outlet	46.0
Width at entrance	250m
Width at outlet	125m
Side slope (horizontal to vertical)	4:1
Flow velocity with water surface El. 50.5	0.45m/s
Flow velocity with water surface El. 49.5	0.65m/s

Headrace Canal

Length from Hestvatn shoreline	850m
Bottom elevation at shoreline	40.0
Bottom elevation in rock excavation	38.5 to 38.0

Bottom width in soil excavation	35m
Bottom width in rock excavation	20m
Side slope in soil (horizontal to vertical)	5:1 to 2:1
Side slope in rock	1/6:1
Maximum flow velocity (Q=390 kl/s)	
(a) Water surface elevation 50.5	1.40 m/s
(b) Water surface elevation 49.0	1.60 m/s

Tailrace Canal

Length	200m
Bottom elevation	25.0
Bottom width	32m
Flow velocities	
(a) Q=130 kl/s	0.55 m/s
(b) Q=260 kl/s	1.00 m/s
(c) Q=390 kl/s	1.40 m/s

Powerhouse

Type	Integral Intake-Powerhouse

Turbines

Type	Kaplan
Number	
Initially	2
Ultimately	3
Rated Net head	16.5 meters

Capacity at minimum net head (15.0m)	26,000 metric HP
Speed	136 RPM
Fishladder	
Length	200m
Slope (horizontal to vertical)	10:1

Generators

Rated capacity	22,500 kva
Power factor	0.9

Transmission Line

Voltage	138 kv
Length - single circuit	65 km
ACSR Conductor size	336.4 MCM

SUMMARY

	Amount Dollars (US)
PRODUCTION PLANT	
Power Plant and Intake, Structures and Improvements	2,438,850
Reservoir, Dams, and Waterways	4,170,150
Turbines and Generators	2,290,000
Accessory Electrical Equipment	270,000
Miscellaneous Power Plant Equipment	250,000
Roads	125,000
Total Production Plant	9,544,000
TRANSMISSION PLANT	
Hestvatn Substation	611,000
Irafoss Connection	150,000
Ellidaar Extension	310,000
Transmission Line Hestvatn-Reykjavik	845,000
Total Transmission Plant	1,916,000
Sub-total Direct Cost	11,460,000
Contingencies and Omissions 15% ±	1,740,000
Total Direct Cost	13,200,000
Engineering and Supervision 8% ±	1,050,000
Total Construction Cost	14,250,000
Interest During Construction 8% ±	1,150,000
TOTAL PROJECT INVESTMENT	15,400,000

	Quantity	Unit Price Dollars (US)	Amount Dollars (US)
PRODUCTION PLANT			
POWER PLANT AND INTAKE STRUCTURES AND IMPROVEMENTS			
Cofferdam and pumping		L.S.	20,000
Excavation, common	70,000 m^3	0.70	49,000
Excavation, rock	40,000 m^3	2.30	92,000
Foundation preparation			
Cleaning, wedging, barring		L.S.	25,000
Drilling grout holes	500 lm	15.00	7,500
Grout	100 m^3	85.00	8,500
Concrete (including forms)			
Intake and wing walls	14,000 m^3	43.00	602,000
Substructure	10,150 m^3**	52.00	527,800
Superstructure	870 m^3*	115.00	100,050
Reinforcement	1,100 tons	330.00	363,000
Compacted backfill	10,000 m^3*	1.50	15,000
Gates and Appurtenances			
Intake gates and hoists	4	93,000.00	372,000
Stoplogs		L.S.	25,000
Draft tube gates and hoist		L.S.	25,000
Trashrack	45 tons	600.00	27,000
Architectural		L.S.	100,000
Operator's village		L.S.*	80,000
Total Power Plant and Intake Structures and Improvements			2,438,850

*Thoroddsen's, estimate Alt. 1
**Thoroddsen's estimate Alt. 2

	Quantity	Unit Price Dollars (US)	Amount Dollars (US)
RESERVOIR, DAMS, AND WATERWAYS			
Diversion Dam			
Care of river		L.S.	200,000
Excavation, rock	21,000 m^3	3.50	73,500
Foundation preparation			
Cleaning, barring, wedging		L.S.	20,000
Drilling grout holes	1,000 lm	15.00	15,000
Grout	280 m^3	85.00	23,800
Concrete including forms	13,000 m^3	35.00	455,000
Reinforcement	390 tons	330.00	128,700
Fish-belly gates and hoists	2	135,000.00	270,000
Taintor gates and hoists	3	170,000.00	510,000
Fish-ladder		L.S.	80,000
Miscellaneous		L.S.	50,000
Sub-total Diversion Dam			1,826,000
Diversion Canal and Reservoir			
Dredging in Hestvatn and Hvita River	320,000 m^3	0.55	176,000
Excavation, Common	725,000 m^3	0.60	435,000
Rock groins (El. 51.0)	80,000 m^3	3.50	280,000
Care of water		L.S.	30,000
Sub-total Diversion Canal			921,000

	Quantity	Unit Price Dollars (US)	Amount Dollars (US)
Headrace and Tailrace			
Cofferdam and pumping		L.S.	50,000
Dredging Hestvatn and Hvita River	145,000 m^3	0.55	79,750
Excavation, common	555,000 m^3	0.70	388,500
Excavation, rock	265,000 m^3	2.30	609,500
Rock lining and sand filters of canal slopes	20,000 m^3	3.00	60,000
Miscellaneous			25,000
Sub-total Headrace and Tailrace			1,212,750
Powerhouse Fish Ladder			
Excavation, common	9,000 m^3	0.70	6,300
Excavation, rock	7,000 m^3	2.30	16,100
Foundation preparation		L.S.	5,000
Concrete including forms	1,100 m^3	100.00	110,000
Reinforcement	100 tons	330.00	33,000
Miscellaneous		L.S.	40,000
Sub-total Powerhouse Fish Ladder			210,400
TOTAL RESERVOIR, DAMS, AND WATERWAYS			4,170,150
TURBINES AND GENERATORS			
Turbines and Governors	2	580,000	1,160,000
Generators (22,500 Kva)	2	565,000	1,130,000
Total Turbines and Generators			2,290,000

	Quantity	Unit Price Dollars (US)	Amount Dollars (US)
ACCESSORY ELECTRICAL EQUIPMENT		L.S.	270,000
MISCELLANEOUS POWER PLANT EQUIPMENT		L.S.	250,000
ROADS		L.S.	125,000*
TOTAL PRODUCTION PLANT			9,539,500
TRANSMISSION PLANT			
Hestvatn Substation			
Foundations and structures		L.S.	70,000
Transformers			210,000
Switchgear and Auxiliary Equipment			331,000
Sub-total Hestvatn Substation			611,000
Irafoss Connection		L.S.	150,000
Ellidaar Extention		L.S.	310,000
Transmission Line (138 Kv)			
Single circuit Hestvatn-Reykjavik 65 KM		13,000	845,000
TOTAL TRANSMISSION PLANT			1,916,000

*Thoroddsen's Estimate

APPENDIX C
Sheet 1

RAFORKUMÁLASTJÓRI
THE STATE ELECTRICITY AUTHORITY

THE STATE ELECTRIC POWER WORKS
THE STATE ELECTRICAL INSPECTION
PROJECTS & SURVEYING DEPARTMENT
GEOTHERMAL RESEARCH

P.O. BOX 40, REYKJAVÍK
ICELAND
TELEGRAMS & CABLES:
RARIK

Harza Engineering Company Int.
400 West Madison Street
CHICAGO, Ill.
U. S. A.

YOUR REF.	YOUR LETTER	OUR REF.	DATE
	7/25/1961	JG RH/-	August 28, 1961.

Subject: Hestvatn Project Planning Review.

Att.: Mr. A.R. Engebretsen Project Manager.

Gentlemen,

We refer to your letter of July 25th. The Hydrological Report on the Hestvatn Project was sent to you some time ago, and another Report on a study of the energy output of the Development when operated integrated with the existing South-West Iceland Power System has been sent to you a few days ago.

In what follows, the points mentioned in your letter will be discussed in the same order as they appeared there.

1. Topography

All the available topography relating to the Project has been forwarded to you. As to the area between the spillway and Vördufell, although we realize that a more detailed mapping of that area is required, that work cannot be carried out in the present season, so that this part of the Planning Review will have to be restricted to what can be done with the existing topography.

2. Hydrography

It was intended in this season to explore by seismic methods the channel of Hvítá River in the reach from the proposed powerhouse to below the rock sill at Háaberg. However, owing to various reasons, among them a present conflict between engineers and their employers regarding salaries, this exploration can presumably not be completed in the present season. The Review, therefore, will have to be based on the tailwater elevation assumed in Thoroddsen's Report, without regard to the possibility of increasing the head by blasting the rock sill mentioned above.

3. Contractors, labour and materials

The civil engineering work of the Hestvatn Development will presumably be subjected to a - possibly more or less restricted - international bidding. The contractor selected might be a domestic or a foreign firm (or firms) or a consortion of both local and foreign firms. The last possibility is probably the most likely one, although nothing definite can be said on this point at present. The contractor would undoubtedly use local labour and material to the extent feasible.

4. Wages

The present wage rates and other labour conditions applicable in Iceland to-day are shown in Enclosure 1. It should be noted in this connection that a wage rise of 13% approx. has occured since the completion of Thoroddsen's Project Plan Report.

5. Materials

The retail prices of main construction materials in Iceland are at present as follows:

Reinforcing steel	kr. 8 300.00	pr.metric ton
Timber	" 93.60	" cubic foot
Cement (from the local cement plant)	" 1 267.00	" metric ton

Owing to a devaluation of the Icelandic currency that took effect early this month, the above prices for steel and timber are ca. 13% higher than at the time when Mr. Thoroddsen was preparing this estimate. The corresponding rise in the cement price is 9.7%.

6. Taxes and duties

The taxes and duties on construction materials and electrical equipment as at present are shown on Enclosure 2.

Taxes and duties on construction equipment differ appreciably, depending on the type of equipment, so that definite figures cannot be stated. In most cases, however, the duties and taxes would amount to between 30 and 40% of the cif-price of the equipment.

In this connection it may be mentioned that there has been a case where a foreign contractor, undertaking a job in Iceland, has been refunded the taxes and duties of that part of his imported equipment which he brought back with him upon completion of his job. It is by no means certain, however, that this case would constitute a precedent for a similar treatment of other foreign contractors in the future.

RAFORKUMÁLASTJÓRI

August 28, 1961.

7. Exchange rate

The official rate of exchange of the Icelandic krona is at présent US $ 1.00 = kr. 43.00.

In converting the above figures for wages and prices of materials this exchange rate should be used. However, as already stated, a devaluation of the Icelandic krona has recently taken place so that, when converting the cost figures in Thoroddsen's report, the rate of exchange prevailing of that report should be employed. That rate of exchange, which was the official one prior to the last devaluation, was US $ 1.00 = kr. 38.00.

8. Energy. Annual costs

As stated at the beginning of this letter, we sent you a few days ago, a report on a study of the possible energy output of the Hestvatn Development in a so-called base water year, when operated interconnected with the existing power system in the South-West Iceland. This study only constitutes the initial phase of more elaborate power studies that will be necessary in connection with a final design. Although we would like you to include this last report in your review, in general lines, we agree with you in that it may be premature to include an estimate of the energy cost. However, we feel that it might be useful to have an estimate of annual charges in the review. Such an estimate should be based upon the assumption that the undertaking would be financed entirely by loans raised on the international capital market, and that the development would be totally exempted from taxes, except aforementioned taxes and duties on imported material and equipment.

9. Cost figures in Thoroddsen's Report

It should be noted that the cost figures in Thoroddsen's Report include all cost items including duties, taxes and contractors' fees.

Sincerely yours,

Jakob Gislason
Director General.

ENCL.

RAFORKUMÁLASTJÓRI

August 28, 1961. Enclosure 1.

Labour Conditions in Iceland

Since the 29th of June 1961 the relevant wage rates for daytime work are as follows:

Basic wages for daytime work

A. Unskilled labour

1.cl.	ordinary labour	kr.	22.74
2. "	concreting, steel, hands	"	23.22
3. "	compressor, blastings	"	23.58
4. "	light motorcar operation	"	24.28
5. "	not applicable here	"	24.72
6. "	heavy motorcar operation and repair work	"	26.28
7. "	cement work	"	26.93
8. "	operators of heavy construction machinery	"	28.00

Direct additions to the above rates:

1. Medical expense	1.0%
2. Vaccation allowance	6.0%
3. Legal accident insurance	1.5%
4. Unemployment insurance	1.0%

B. Skilled labour

Carpenters	kr.	26.86
Masons	"	27.70
Mechanics	"	28.00

Direct additions are the same as for unskilled labourers, except that for carpenters an extra 6.0% has to be added for life annuity fund. Tools are included.

Otherwise, labour conditions are the same as described in the "Jökulsá á Fjöllum Report", p.10, except that we recommend to estimate underground work paid with a compensation amounting to kr. 3.10 per hour, and that all labourers are entitled to free catering at kr. 30.00 extra a day.

APPENDIX C
Sheet 5

RAFORKUMÁLASTJÓRI

Reykjavik, August 28th 1961

ENCLOSURE 2.

TAXES AND DUTIES

Material	Specific Duty	Duty ad valorum
Reinforcing steel	0,088 kr/kg	14,4% of Cif-price
Timber	0,44 kr/cubic foot	14,4% " "
Cement (imported)	24,40 kr/metric ton	13,6% " "
Turbines	0,088 kr/kg	14,4% " "
Lock Gates	0,088 "	14,4% " "
Generators	0,088 "	14,4% " "
Transformers	0,308 "	18,0% " "
Other electrical equipm.	0,308 "	18,0% " "

Furthermore, it should be mentioned that all the above mentioned goods are subject to the following duties:

Custom House Duty (2% of total specific duty and duty ad valorem and also on electrical inspection duty if the goods are liable to that duty.)

Sales Duty (16,5% of Cif-price plus other custom duties)

Consumption Sales tax (3,3% of Cif-price plus all other custom duties)

Furthermore, Generators, Transformers and other electrical equipment are subject to electrical inspection duty (0,75% of Fob-price) and finally Transformers are also subject to an import licence duty (1/2% of Fob-price).

APPENDIX C
Sheet 6

Rafmagnsveitur ríkisins
The State Electric Power Works
ICELAND

IMPORT OF GOODS.
ERLEND VÖRUKAUP
ÚTREIKNINGUR KOSTNAÐARVERÐS
Calculation of Cost Price.

ENCLOSURE 3.
Aug.28. 1961.

Seljandi Sender				Reikningur dags. Invoice dated
Vörugreining Article: Electrical Equipment				Leyfi nr. Import Licence / Rarik nr.
Flutt með Shipment by	Komud. Date of Arrival	Farmskr. Consignament Nr.	Stykki Pcs.	Þyngd Weight: 5 kg
Sent Forwarded / Sótt Received		Tollafgr.nr. Customs House No.		Tollskrá Customs Tariff No.

Fob price Innkaupsverð $100.-	4306.-		
Cost abroad Erlendur kostnaður		4306.- (1)	
Freight charges Flutningsgjald	20.-	→	4236.- (S1)
Insurance Vátrygging	14.-	14.- (8)	4340.- (S2)
Specific duty .30 kr/kg Vörumagnstollur	2.-		
Duty ad valorem 18 % af S2 Verðtollur	781.-		(S3)
Elect.insp.duty ¾ % af S2 Rafmagnsegj.	33.-		5156.- (S4)
Custom House duty 2% af S3 Tollstöðvargj. 1% af S4-S3	16.-		
Sales duty 16.5% af S4 Söluskattur	851.-		
Import duty % af S4 Innflutningsgj.	-		6023.- (S5)
Consumption sales tax 3.3% af S5 Viðskiptasölusk.	199.-	1882.- (5)	
Import licence duty ½ % af fob Leyfisgjald	-	- (2)	
Bank charges ca 1% of fob Bankakostnaður	50.-	50.- (3)	
→	20.-		
Unloading Uppskipun	2.-		
Harbour duty Hafnargjald	1.-	23.- (6)	
Harbour storage Geymsla	-	- (7)	
Diverse Annað	-	- (9)	Kostnaðargengi Cost rate of Exchange, $1.- = 62.75 kr.
Total cost price Kostnaðarverð samtals		Kr. 6275.-	

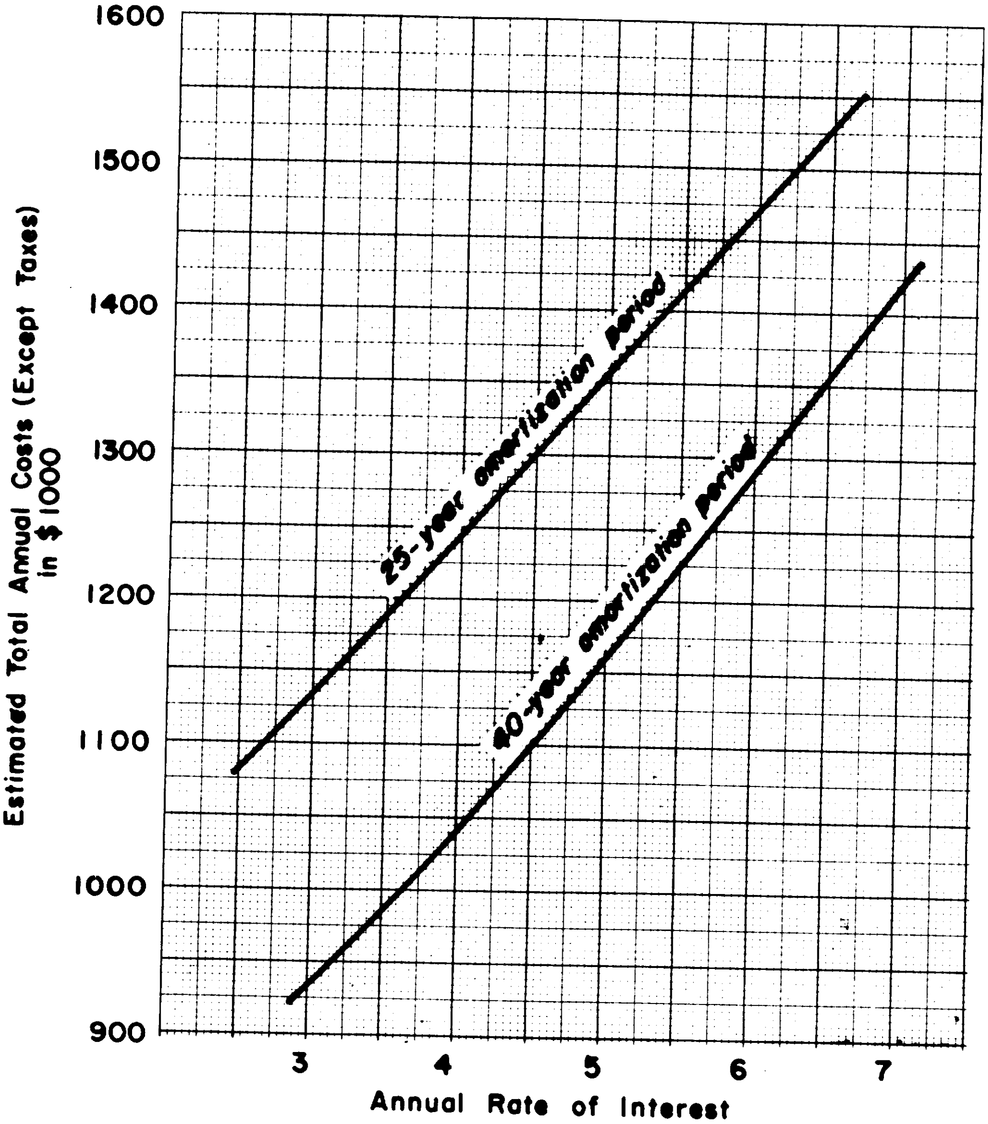
Útreiknað Calculated / 19	Verðlagt Priced / 19

Aths. NB.

46150x10DH

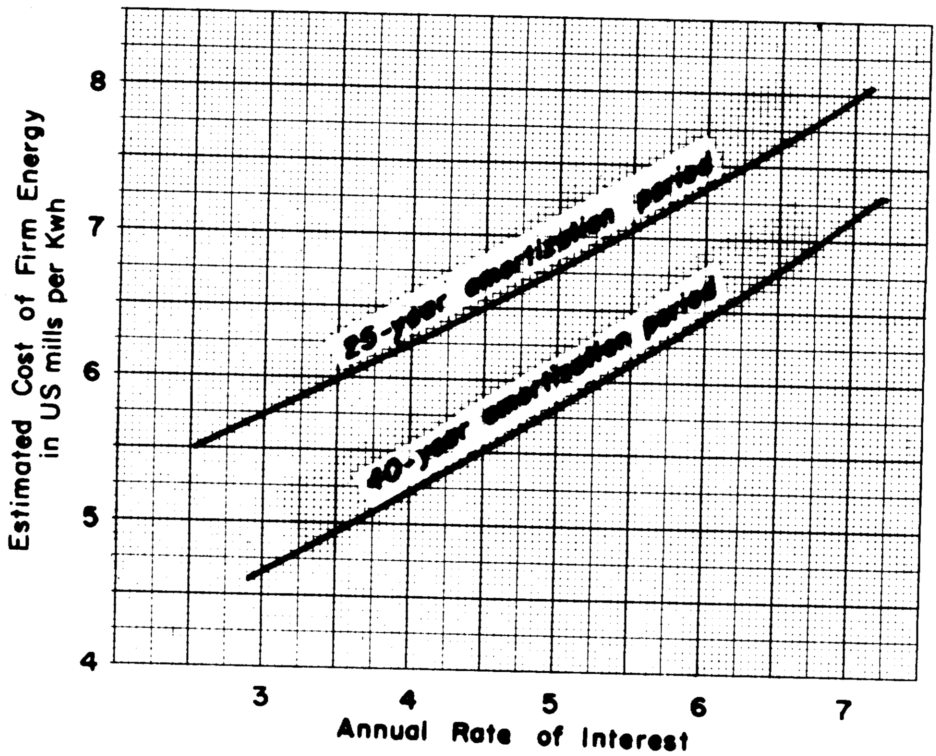
(#1000.

EXHIBIT I



THE STATE ELECTRICITY AUTHORITY ICELAND		
HESTVATN PROJECT		
ESTIMATED ANNUAL CHARGES		
HARZA ENGINEERING COMPANY APPROVED C.K. Willey		
CHICAGO, ILLINOIS	DATE Oct. 1961	DWG. NO. 279 P I

EXHIBIT 2



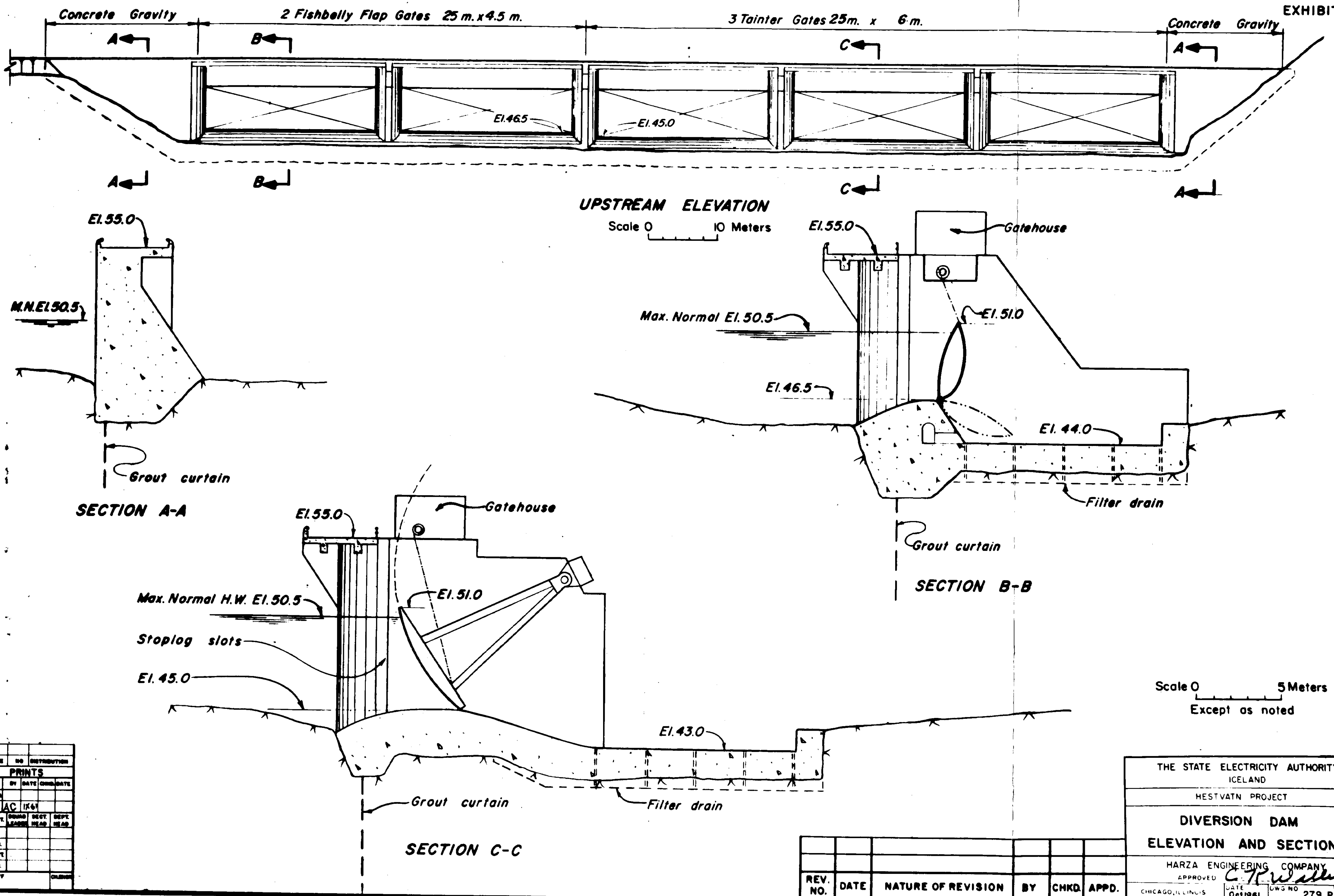
THE STATE ELECTRICITY AUTHORITY
ICELAND

HESTVATN PROJECT

ESTIMATED COST OF ENERGY

HARZA ENGINEERING COMPANY
APPROVED C. K. Willey
CHICAGO, ILLINOIS | DATE Oct 1961 | DWG NO 279 P2

EXHIBIT 3



DATE	NO.	DISTRIBUTION
PRINTS		

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD.	APPD.

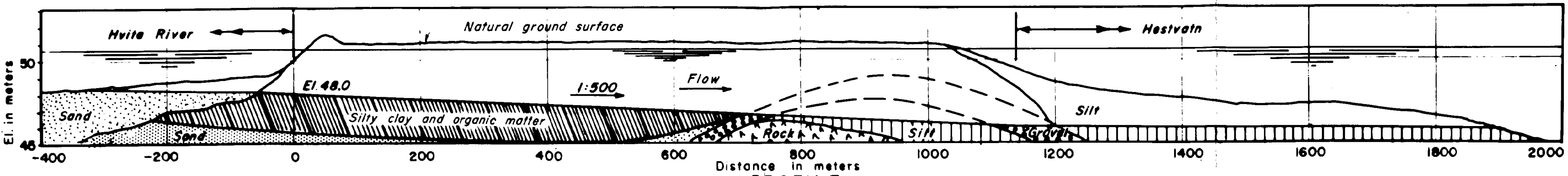
THE STATE ELECTRICITY AUTHORITY
ICELAND

HESTVATN PROJECT

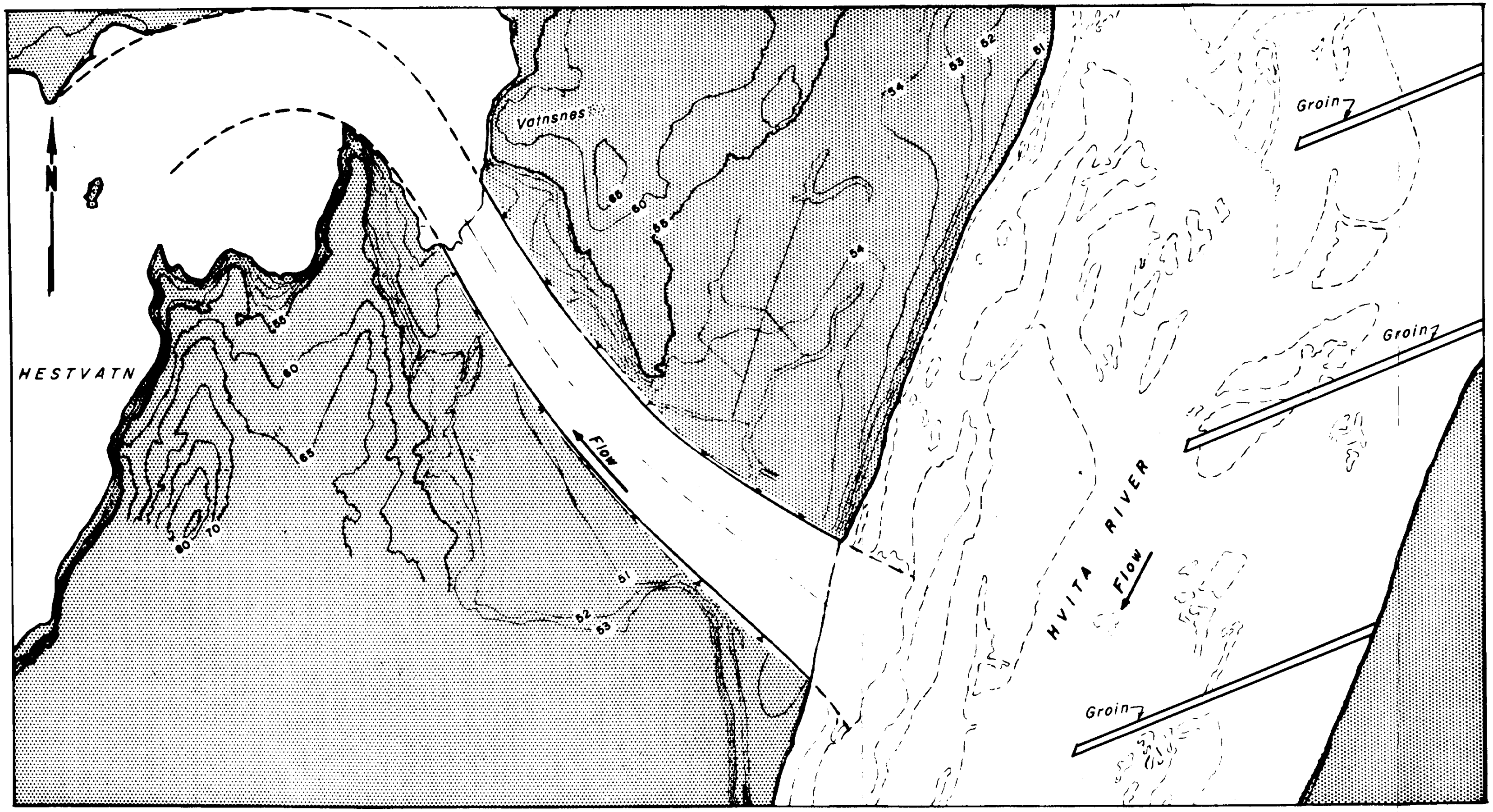
DIVERSION DAM
ELEVATION AND SECTIONS

HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS
DATE Oct 1961
DWG NO 279 P 3

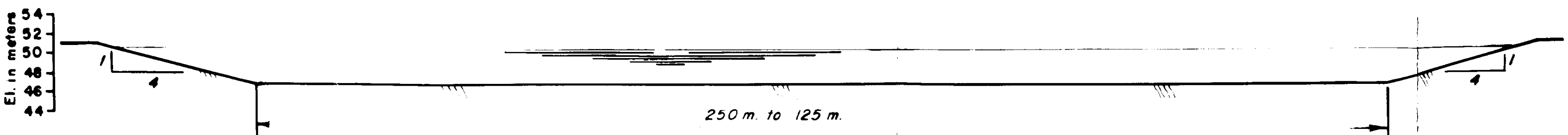
EXHIBIT 4



PROFILE



PLAN



TYPICAL SECTION OF CANAL

NOTE

Position of groins subject to further study, possibly by model tests

Scale 0 100 200 300 Meters
Except as noted

THE STATE ELECTRICITY AUTHORITY
ICELAND

HESTVATN PROJECT

DIVERSION CANAL
PLAN AND SECTIONS

HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS | DATE Oct. 1961 | DWG NO 279 P 4

EXHIBIT 5

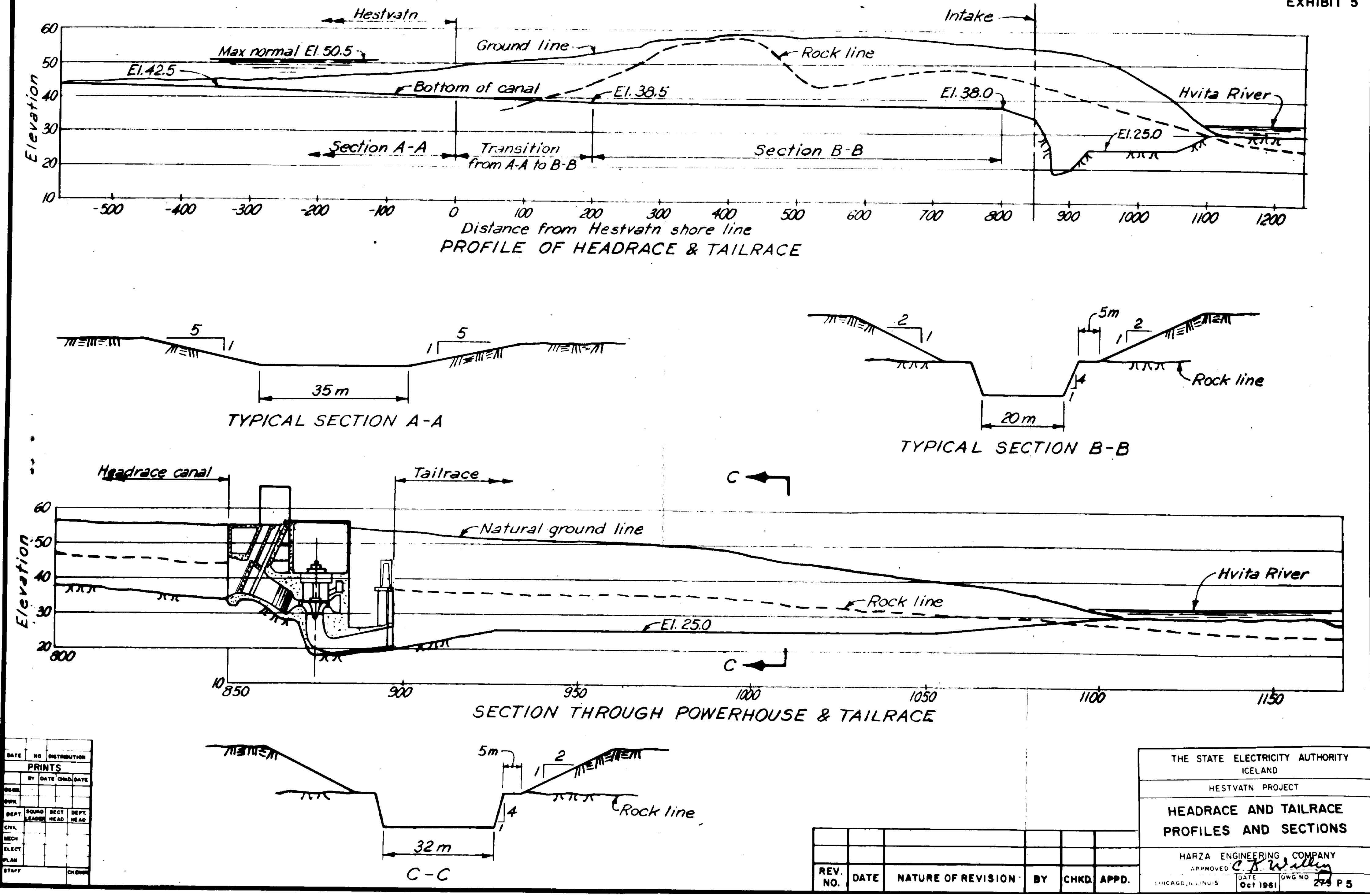
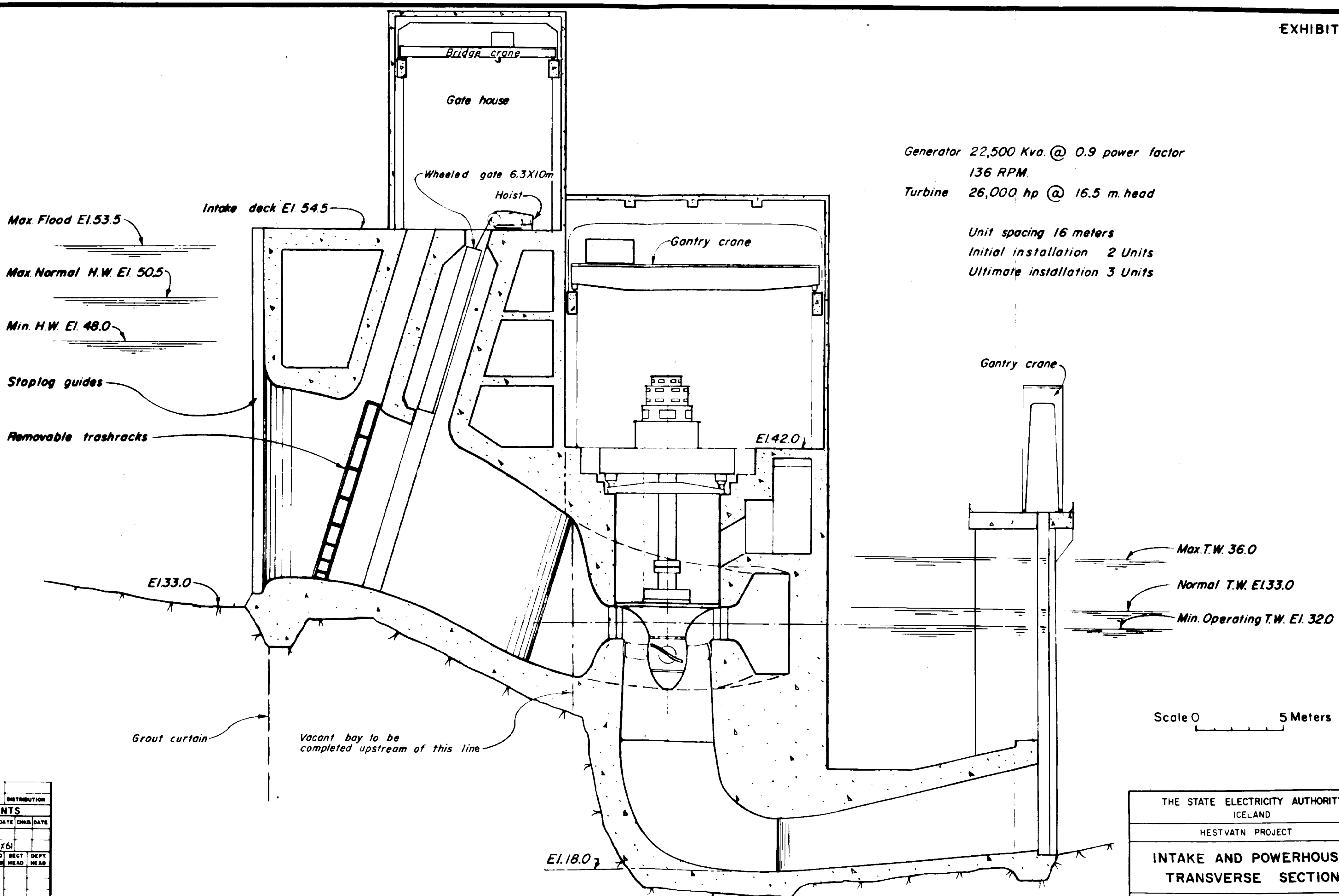

Hestvatn
Intake
Max normal El. 50.5
Ground line
Rock line
El. 42.5
Bottom of canal
El. 38.5
El. 38.0
Hvita River
El. 25.0
Elevation
Section A-A
Transition from A-A to B-B
Section B-B
Distance from Hestvatn shore line
PROFILE OF HEADRACE & TAILRACE
35 m
TYPICAL SECTION A-A
5m
Rock line
20 m
TYPICAL SECTION B-B
Headrace canal
Tailrace
Natural ground line
Hvita River
Rock line
El. 25.0
SECTION THROUGH POWERHOUSE & TAILRACE
5m
Rock line
32 m
C-C
THE STATE ELECTRICITY AUTHORITY
ICELAND
HESTVATN PROJECT
HEADRACE AND TAILRACE
PROFILES AND SECTIONS
HARZA ENGINEERING COMPANY
APPROVED
CHICAGO, ILLINOIS
DATE Oct 1961
DWG NO
REV. NO.
DATE
NATURE OF REVISION
BY
CHKD.
APPD.
PRINTS

EXHIBIT 6



Generator 22,500 Kva. @ 0.9 power factor
136 RPM.
Turbine 26,000 hp @ 16.5 m. head

Unit spacing 16 meters
Initial installation 2 Units
Ultimate installation 3 Units

DATE	NO	DISTRIBUTION
PRINTS		

	BY	DATE	CHKD.	DATE
DSGN.				
DWN.	AC	1X61		
DEPT.	SQUAD LEADER	SECT HEAD	DEPT HEAD	
CIVIL				
MECH.				
ELECT.				
PLAN				
STAFF			CH.ENGR	

H-E PHOENIX R100 TRACING CLOTH

THE STATE ELECTRICITY AUTHORITY
ICELAND

HESTVATN PROJECT

INTAKE AND POWERHOUSE TRANSVERSE SECTION

HARZA ENGINEERING COMPANY
APPROVED C. R. Walley

CHICAGO, ILLINOIS | DATE Oct 1961 | DWG NO 279 P 6